

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CANADIAN SOLAR INC.,
Petitioner,

v.

MAXEON SOLAR PTE. LTD.
Patent Owner

Inter Partes Review No. IPR2024-01038¹

Patent No. 11,251,315

PETITIONER'S REPLY TO PATENT OWNER RESPONSE

¹ IPR2024-01194 has been consolidated with the instant proceeding.

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The Institution Decision correctly found claims 10-16 and 19 of the 315 Patent obvious over the prior art. Patent Owner's Response focuses on two issues: (1) whether metal impurities would inherently getter to the emitter region of Li's solar cell, and (2) motivation to combine Li's solar cell with the frontside dopant concentration indisputably disclosed in King, Swanson-352, Marvin, and Muller. Petitioner met its burden on both issues.

I. PETITIONER HAS DEMONSTRATED THAT METAL IMPURITIES WOULD NECESSARILY GETTER TO THE POLYSILICON EMITTER REGION OF LI'S SOLAR CELL

Maxeon's arguments against inherent gettering focus on *how many* metal impurities would be present initially in Li's silicon substrate, and *how many* of those impurities would enter Li's doped polysilicon region. POR, 13. Neither of these arguments undermine Petitioner's showing of inherent gettering.

A. Petitioner Has Shown Li's Starting Silicon Substrate Would Contain Metal Impurities

Maxeon presents a hypothetical that Li might have utilized a "pure or near pure ('impurity free') silicon substrate. POR, 4, 15. Yet nothing in Li suggests the use of a non-standard multicrystalline silicon substrate. Rather, Li states that its silicon substrate may be "multi-crystalline" silicon, *i.e.*, the type of commonly-used silicon recognized to have unavoidably high concentrations of iron and other metals impurities. Pet., §V.A.3; EX1005, ¶43; EX1003, ¶¶88-90, 157; EX1018, 1;

EX1022, 66; *Allergan, Inc. v. Apotex Inc.*, 754 F.3d 952, 959 (Fed. Cir. 2014) (a disclosure that optionally includes a particular component still anticipates).

Maxeon incorrectly contends Li's silicon substrate "would ***not*** include high levels of impurities" because SunPower (assignee of Li) used wafers with "high lifetime[s]." POR, 14-15. Maxeon ignores, however, that SunPower ***is also the original assignee of the 315 Patent***, and David Smith is an inventor on both the 315 Patent and Li. EX1087, 66:3-9. Yet the 315 Patent (like Li) describes use of standard single-crystalline or multicrystalline substrates, without specifying that a particular method to manufacture or clean the substrate. EX1001, 3:35-36, 4:65-5:9, 8:40-50, 9:1-9; EX1087, 29:20-30:10, 124:1-20, 146:16-148:22. Maxeon's expert Dr. Carroll agrees that, around 2014, "low-quality silicon" would have been used for solar cells. EX1087, 24:4-26:18, 28:18-29:18.

Maxeon further argues "[i]n 2014 substrates with impurity concentrations as low as 10^{11} or 10^{12} were "widely known." POR, 14. But for "solar cells" utilizing the "multicrystalline" substrates, Seibt confirms the presence of "high concentrations" of "metal impurity content" such as iron in the range of " 10^{14} - 10^{16} cm⁻³." EX1016, 696. Indeed, even as of 2018, "[i]mpurities such as transition metals [were] ***commonly found*** in silicon wafers for solar cells." EX1029, 136-

137 (noting iron's "pervasiveness in solar-grade silicon").² Even Dr. Carroll admits that typical solar-grade silicon substrate used in 2014 would have had "substantial" metal impurities on the order of at least 10^{15} cm^{-3} . EX1087, 28:18-29:14, 150:22-151:4, 153:9-16. These high metallic concentrations were a "general concern to the silicon industry," and the reason "incorporation of gettering steps into the processing scheme is a *prerequisite* for the production of efficient solar cells." EX1025, 3773; EX1016, 696; EX1003, ¶¶82-83, 88-90.

Hajjiah and Coletti do not support Maxeon's purportedly "low" level of metal impurities. For example, Hajjiah, a 2020 reference, reported iron concentration in *single-crystal/monocrystalline* silicon substrates between 3.5×10^{12} and $2.7 \times 10^{14} \text{ cm}^{-3}$. EX2032, 1. Hajjiah characterized the low end of this range as a "*very low* Fe contamination concentration[]," contrasted with the "*significant quantities* of Fe, Cr, Cu, Mo, and Co" "common in photovoltaic grade crystalline silicon." *Id.* Hajjiah also noted that "[i]ron is a *very common* element" and "*difficult to eliminate* on a production line" which results in "unintentional iron contamination level in wafers [that] is usually higher than that of other metal impurities," with the "*typical* concentration of iron... in commercial multi-crystalline silicon ingots... reported to be in the range of 10^{13} - 10^{15} cm^{-3} ." EX2032,

² All emphasis added unless otherwise noted.

1-2. Coletti likewise confirms that “[i]n practice, substrates are *dominated* by... impurities” with “severe impact on device performances.” EX2033, 1164; *id.* at 1167 (noting “high level of metal contamination” in silicon substrates). Coletti also noted substantial concentrations of copper and nickel, which were known as “fast or relatively fast diffusing impurities” that are “*more sensitive to gettering*” than iron. EX2033, 1167; EX1087, 30:11-31:22.

Maxeon criticizes Dr. Banerjee's opinions as “based on perceived ‘costs.’” POR, 15. Not so. Dr. Banerjee testified he was “not aware of commercial cells with ... low level[s] of metallic impurities” and that instead a metallic impurity concentration in the range of 10^{14} - 10^{16} cm⁻³ would be consistent with “the typically high numbers that... [he] saw for multi-crystalline cells.” EX2022, 83:12-85:17. He explained that when he referred to the “cost point of view,” he was referring to use of “multi-crystalline silicon, which is not single-crystal silicon.” *Id.*, 76:2-13. Dr. Banerjee explained that multi-crystalline silicon “was very often what is used for solar cells,” and in fact Li expressly states that the silicon substrate may be multi-crystalline silicon. *Id.*; EX1005, ¶0042; EX1087, 67:3-68:12, 70:11-22. Further, he confirmed that, *regardless of cost*, it would “impossible, if not practically impossible” to implement a silicon substrate “with no impurities.” EX2022, 76:14-77:10. Dr. Carroll agrees, arguing only that metallic impurity

concentration could be “*as low as* 10^{11} or 10^{12} .” EX2021, ¶¶50, 52-53; EX1087, 149:11-150:1.

Maxeon's suggestion that Li could have utilized “pure or near pure” silicon substrates with “*extraordinarily* high lifetime” is legally irrelevant. POR, 4, 15

As the Federal Circuit has held, “a product would be inherently anticipated where it was a natural result of the prior art process, even when it would be possible to prevent the formation of the production through ‘*extraordinary measures*.’”

Allergan, 754 F.3d at 961 (quoting *Atlas Powder Co. v. Ireco, Inc.*, 190 F.3d 1342, 1349 (Fed. Cir. 1999)). Here, Maxeon's arguments against inherency are explicitly (and improperly) premised on *extraordinary* silicon substrates with no or minimal metal impurities, *i.e.*, those that require extreme time and cost to make and are not “typically” used for solar-grade products. POR, 14-16; EX1087, 142:5-143:20, 150:2-21, 153:17-154:16.

B. Gettering of Metal Impurities Through Li's 1-2 nm Silicon Oxide Layer Under Heating at 950°C Is the Natural Result of Li

To demonstrate inherency, “[a]ll that needs to be shown is that the outcome of the process be a ‘*natural result*’ flowing from the operation as taught in the prior art.” *Allergan*, 754 F.3d at 961 (quoting *In re Oelrich*, 666 F.2d 578, 581 (C.C.P.A. 1981)). While an inherent disclosure “can be found based on a trace amount” of the limitation being present in the prior art, that is not the only means by which to demonstrate inherency. *Id.* (citing *SmithKline Beecham Corp. v.*

Apotex Corp., 403 F.3d 1331, 1344 (Fed. Cir. 2005) and *Atlas Powder*, 190 F.3d at 1346). Here, Petitioner has demonstrated that the “natural result flowing from” Li’s doping process (heating dopant source layers above 900°C) would necessarily result in metal impurities being gettered from the silicon substrate, through the dielectric layer, and into the doped polysilicon regions, in the same way as is described in the 315 Patent. *Allergan*, 754 F.3d at 961; EX1003, ¶¶155-170; Pet., §§V.A.3, VI.G.1.v.

Maxeon argues the Petition failed “to show that any metal impurities that are originally present in Li’s substrate 508 would travel to Li’s material layer 506 in a **recognized and non-*de minimis*** amount.” POR at 13. Maxeon is wrong.

First, there is no requirement that metal impurities in the polysilicon layer must have been “recognized.” POR, 13. Such a standard vitiates the doctrine of inherency. *SmithKline Beecham Corp.*, 403 F.3d at 1343 (inherency “does **not** require a person of ordinary skill in the art to recognize the inherent disclosure in the prior art at the time the prior art is created”); *W.L. Gore & Assocs. v. Garlock, Inc.*, 721 F.2d 1540, 1548 (Fed. Cir. 1983); *MEHL/Biophile Int’l Corp. v. Milgraum*, 192 F.3d 1362, 1366 (Fed. Cir. 1999); *Verdegaal Bros., Inc. v. Union Oil Co. of Cal.*, 814 F.2d 628, 632-33 (Fed. Cir. 1987); *Schering Corp. v. Geneva Pharms.*, 339 F.3d 1373, 1377 (Fed. Cir. 2003).

Second, the 315 Patent puts no limitation on the **amount** of metal impurities present in the polysilicon. As the Federal Circuit has held, in rebutting inherency “it is inappropriate for [patent owner] to rely [a] distinction” that does not appear as a “limitation in the subject claims.” *Verdegaal*, 814 F.2d at 632. Simply put, “to inherently anticipate, the prior art need only give the same result as the patent, not better.” *King Pharms., Inc. v. Eon Labs, Inc.*, 616 F.3d 1267, 1275-76 (Fed. Cir. 2010).³

Third, Li's disclosure is identical or more detailed than the 315 Patent's in all material respects relevant to gettering. EX1003, ¶¶144-151, 170. Like the 315 Patent, Li discloses a “back-contact solar cell” (EX1005, ¶0003), with a “multi-crystalline” silicon substrate (EX1005, ¶0037), (iii) a “tunnel” “silicon dioxide” “dielectric film” of thickness “1-2 nanometers” (EX1005, ¶¶0039, 0043), (iv) a doped polycrystalline layer of unspecified thickness and concentration (EX1005, ¶0037). As shown below, the dielectric layer in Li and in the 315 Patent (purple)

³ At his deposition, Dr. Carroll acknowledged that Li's n-type and p-type dopants in the polysilicon are also “metal impurities,” which satisfy the limitations of claims 10 and 16 of the 315 Patent because gettering is not required. EX1087, 34:13-37:8, 122:22-123:11.

have interfaces with both the polysilicon and the silicon substrate. POR, 16-17; EX1087, 183:10-184:19.

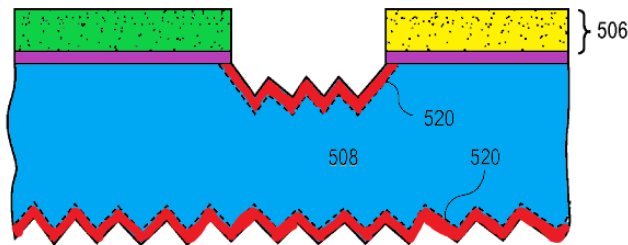


FIG. 5E

Li

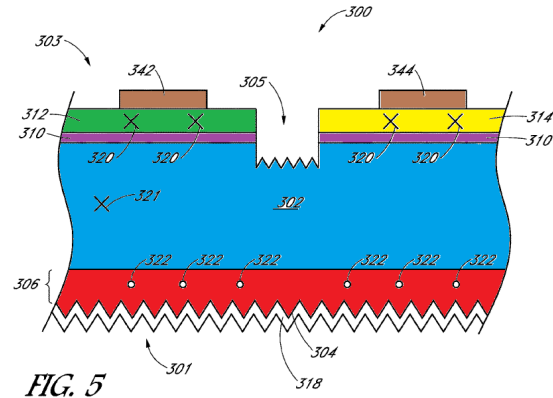


FIG. 5

315 Patent

As in the 315 Patent, in Li dopants are transferred to the polysilicon from dopant source layers during a heating process at over 900°C (“approximately 950 degrees Celsius”) for an unspecified length of time. EX1005, ¶¶0033, 0045.⁴ Under these

⁴ Dr. Carroll argues the 315 Patent and Li “use different doping processes and high-temperature heating steps.” EX2021, ¶¶ 100-108. But, in the 315 Patent, (i) gettering into the polysilicon is shown to occur regardless of the dopant concentration on the front surface, (ii) “any appropriate process” including gaseous doping as in Li (EX1005, [0049]) (e.g., chemical vapor deposition) can be used to dope the front portion of the silicon substrate, and (iii) one or multiple heating steps may be utilized (as in Li). EX1001, 4:32-41, 5:26-57, Fig. 11; EX1087,

conditions (which satisfy the critical $>900^{\circ}\text{C}$ condition) the 315 Patent states that metal impurities will getter from the silicon substrate, through the silicon oxide, and into the polysilicon. EX1001, 5:18-26, 8:40-50;9:1-9, Fig. 11 (showing that in both examples in which the solar cell was “heated at a temperature above 900 degrees Celsius” the result was “gettering in a polysilicon region of the silicon substrate,” regardless of front surface dopant concentration). Indeed, Li’s 50°C higher temperature would *increase* the gettering effect. EX1087, 78:21-79:12, 185:9-18. Thus, “to the extent the embodiment in the [315] patent achieves [gettering of metal impurities into the polysilicon], so does the [Li] method.” *MEHL*, 192 F.3d at 1366.

Maxeon argues lack of inherency because certain alleged “key characteristics” of Li’s solar cell—*e.g.*, the starting concentration of metal impurities in the substrate, the alleged “pileup” effect of the dielectric layer, the thermal history of the solar cell, thickness and dopant concentration of the polysilicon layer, and duration of the heating step—are not explicitly disclosed. POR, 14-32. But importantly, “the prior art need only meet the inherently

128:9-21, 131:15-133:2 . Thus, the 315 Patent contemplates the same frontside doping and heating as Li.

disclosed limitation to the extent the patented method does.” *King Pharms.*, 616 F.3d at 1275-76.

Here, Maxeon ignores that the *same details* are also missing in the 315 Patent's disclosure, yet gettering is reported to have occurred. EX1001, 8:40-50, 9:1-9, Fig. 11. For example, the 315 Patent's "emitter region" of "polysilicon" "can be formed using any appropriate process" (without a specified thickness) and can be "doped" to an unspecified concentration with p-type or n-type dopants. EX1001, 4:32-54; EX1087, 131:15-134:8. The starting concentration of metal impurities in the 315 Patent's silicon substrate is unspecified. EX1001, 3:36-37, 4:65-5:9; EX1087, 124:1-20. Further, the heating step "can include placing the solar cell in [a] thermal tool, e.g., a thermal furnace" and raising the temperature above 900°C for an unspecified length of time, can "drive dopants from the emitter dopant region to the emitter region," and can consist of only one heating step for the front and back surfaces or multiple steps. EX1001, 4:3-7, 5:26-57; EX1087, 127:6-128:21. Finally, the "dielectric region" "can be a tunnel oxide" of "silicon oxide" and "can be grown and/or formed through a thermal process," or "*any appropriate process.*" EX1001, 3:38-61; EX1087, 129:5-132:19. Yet the only condition the 315 Patent describes as "insufficient to diffuse metal impurities through a tunnel oxide and into a polysilicon region" is heating at below 900°C. EX1001, 5:18-20; EX1087:134:9-140:17.

The omission of these details from the 315 Patent precludes Maxeon from using those same details to argue against Li's inherent disclosure of gettering. In *King Pharms.*, the patentee argued that prior art failed to inherently disclose the claimed increase in bioavailability of metaxalone by administering it with food because the art was allegedly "vague as to the conditions under which the food was administered." 616 F.3d at 1274. The Federal Circuit rejected this argument, holding that "[b]ecause the [challenged] patent discloses no more than taking metaxalone with food, to the extent such a method increases the bioavailability of metaxalone, the identical prior art method does as well." *Id.* at 1275-76; *In re Wiegand*, 182 F.2d 633, 636-37 (C.C.P.A. 1950) (inherency established through "the similarity of the process" described in the patent and prior art). So too here, the Board should reject as "untenable" Maxeon's "attempt to link" gettering of metal impurities into the polysilicon layer to undisclosed and unclaimed characteristics of the 315 Patent's solar cell or its manufacturing process because "the claims only recite" the presence of metal impurities in the polysilicon without any "specific conditions" that must be met for gettering to occur. *King Pharms.*, 616 F.3d at 1275; EX1087, 63:4-13.

Fourth, Maxeon has failed to demonstrate that iron detection limits are relevant here. As Petitioner has explained, processes for gettering metal impurities from commercial grade multicrystalline silicon was well-known before 2014. Pet.,

§§V.A.3, VI.G.1.v; EX1003, ¶¶155-170. This case is thus unlike *In re Seaborg* and its progeny, in which a previously-undisclosed element or compound had not been shown to have been produced in non-*de minimis* amounts before the priority date. 328 F.2d 996, 998-999 (C.C.P.A. 1964) (claim to new element not inherently anticipated where record showed, at most, potential prior art production was “in such miniscule amounts [‘one billionth of one gram’]... that its presence was undetectable”); *Schering Corp. v. Geneva Pharms.*, 339 F.3d 1373, 1379 (Fed. Cir. 2003) (applying *Seaborg*’s “detection” standard to assessment of whether previously-unrecognized metabolite resulted from prior art process). The 315 Patent does not claim to have discovered gettering or metal impurities, so the analysis should focus on whether gettering “is the ‘natural result’ flowing from the reference’s explicitly explicated limitations,” even if that characteristic is only present in a “trace” amount. *See Eli Lilly & Co. v. Barr Labs., Inc.*, 251 F.3d 955, 970 (Fed. Cir. 2001); *Allergan*, 754 F.3d at 961 (“a chemical process that produces only a ‘trace’ amount of a compound inherently anticipates that compound”); *SmithKline Beecham*, 403 F.3d at 1344 (inherency shown where prior art process “inevitably results in the production of at least trace amounts of anticipating PHC hemihydrate”); EX1087, 71:11-18.

Finally, Maxeon fails to support its assertion that “[b]y definition, a ‘trace’ amount is able to be detected.” POR, 35. Its cited case, *Ex Parte Nye*, held that

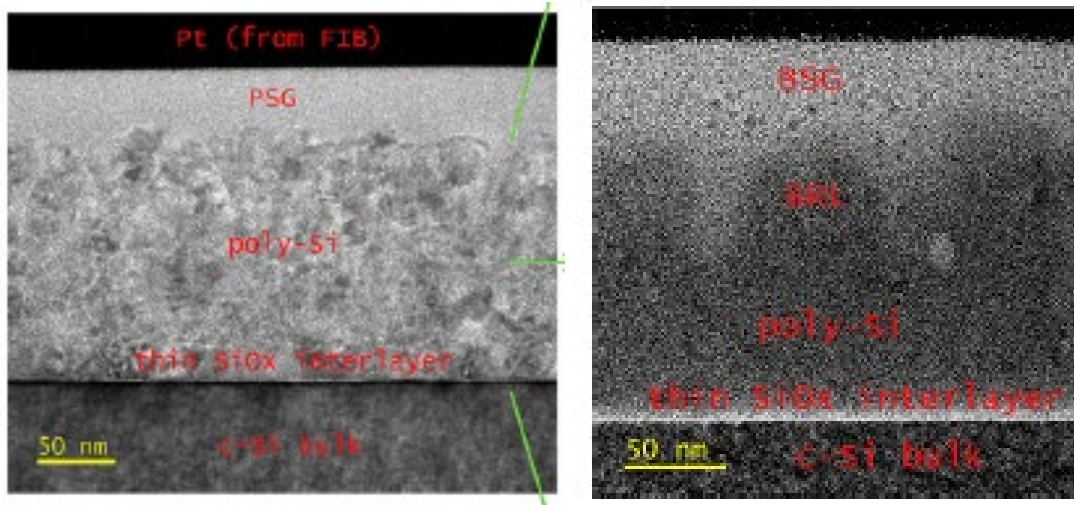
the burden of establishing inherency amounted to merely showing that “*at least a molecule*” of the claimed compound was “necessarily... produced” as the “natural result” of the prior art processes, without any mention of whether that one molecule could have been detected. No. 2010-001708, 2011 WL 3798745, at *6 (B.P.A.I. Aug. 25, 2011). Here, even under Maxeon’s unfounded hypotheticals, it is undisputed that “trace” amounts of metal impurities would getter from Li’s silicon substrate, through the silicon oxide, and into Li’s polysilicon layer. POR, 19-21; EX1087, 85:1-16, 88:1-5 (confirming “a small number of iron impurity atoms would [getter] through the silicon oxide and into the polysilicon”), 87:18-22 (“Q. And you are not providing an opinion in your declaration that no metal impurities whatsoever would getter through [Li’s] 1-2 nanometer silicon oxide layer and into the polysilicon layer, correct? A. **No, I am not.**”). This distinguishes *Seaborg*, in which there was “only a *possibility* that some unknown, possibly very small amount of a [claimed compound] *may* have actually been produced.” *Nye*, 2011 WL 3798745, at *5. Nevertheless, Dr. Carroll also admitted at his deposition that there *were* available detection methods that could have detected the concentrations of iron he concedes would have gettered into Li’s polysilicon region. EX1087, 85:12-87:22; *see* EX1029, 137 (noting “easy, accurate quantification techniques” to measure iron in “solar-grade silicon”); EX1025, 3773-74 (detecting iron at 7×10^{10} atoms/cm³).

C. **Maxeon Mischaracterizes the Art's Teachings Regarding Gettering**

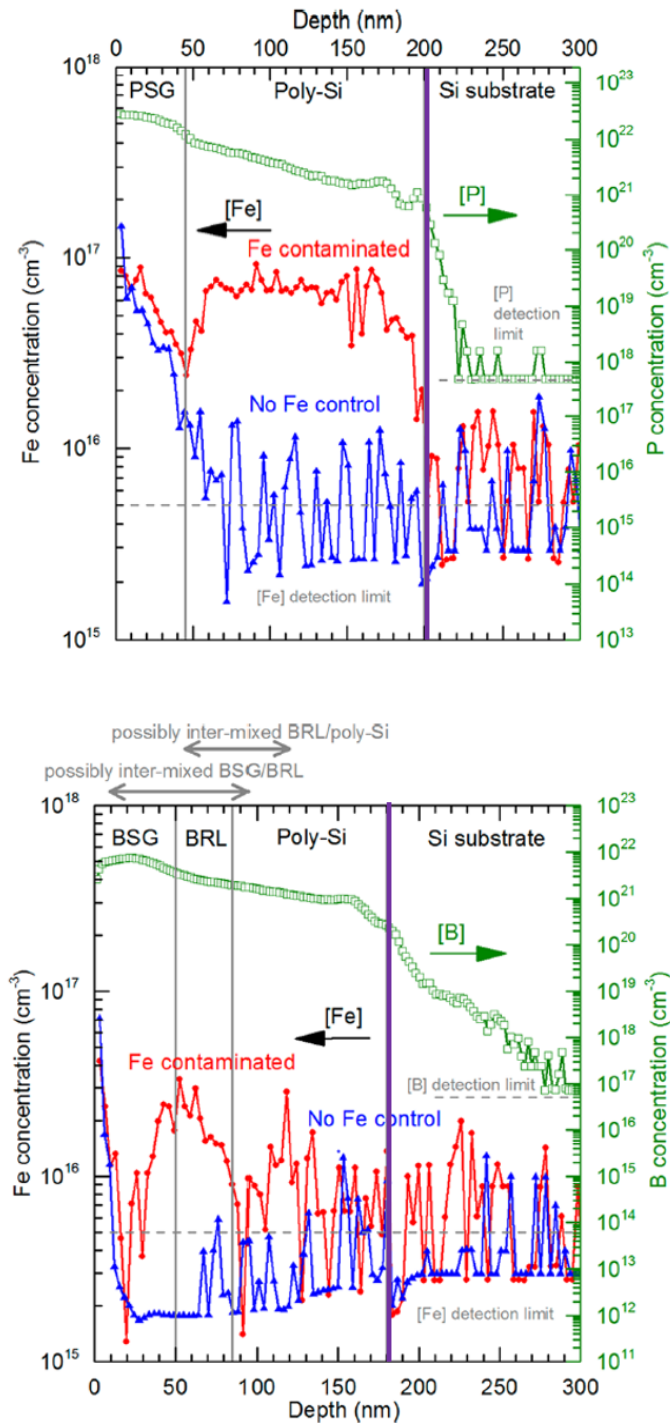
Maxeon's assertion that "it was not known whether high-temperature heating would getter impurities through the dielectric region" rests on numerous mischaracterizations of the art. POR, 9.

Maxeon points to Ramappa's finding that metal impurities may accumulate at the oxide interface. POR, 16-18. However, Ramappa confirmed that iron readily passes through the interface between the silicon oxide and silicon substrate, even with undoped surfaces and extremely thick oxides. EX1025, Fig. 5; EX1087, 81:15-82:19. Ramappa also observed that metal impurities such as iron "exhibit[] *very high diffusivity* (10^{-6} cm²/s at 900°C) and solubility (2×10^{13} cm⁻³ at 900°C) in silicon." EX1025, 3773.

Further, Liu-1 and Liu-2 each addressed a three-layer stack of silicon, thin tunnel oxide (1.3 nm), and polysilicon, which, just as in Li and the 315 Patent, has two oxide interfaces between the silicon and polysilicon. EX1029, 138, 141, Figs. 1, 3; EX1028, 2276, Figs. 1-2, 5 (1.3-1.4 nm oxide thickness); EX1087, 91:14-94:11, 104:10-105:13.



Liu-2 reported a “***strong gettering effect***” despite oxide interfaces, thus obviating any significant “pileup” effect. EX1029, 141. Liu-2 further noted that at “very thin oxides combined with sufficiently high diffusion temperatures,” any “blocking effect” caused by “oxide interlayers” is “small, enabling the removal of more than **99.9%** of the bulk iron” from the silicon substrate. EX1029, 141. Notably, Liu-2 used an oxide of the same thickness disclosed in Li (1.3 nm v. 1-2 nm) and similar processing temperatures (reporting results for temperatures between 780-1000° C compared to Li’s 950°C). EX1029, Fig. 3. Liu-1 reported iron diffused in substantial quantities through silicon oxide interfaces (annotated below with a purple line) and into polysilicon:



EX1028, Figs. 4, 7; EX1087, 100:16-101:7.

Moreover, while Ramappa noted a tendency of iron to “pileup” at SiO_x-Si interfaces, Ramappa demonstrates a significant quantity of iron passes through

Ramappa's thick oxide (1200 Angstroms), which is 100 times thicker than Li's 1-2 nm oxide. EX1025, 3776; EX1005, ¶0039; EX1087, 81:15-84:4. As Dr. Banerjee explained at his deposition, "Ramappa shows that even for much, much thicker oxides, iron on the surface is able to diffuse through," so "*certainly for 1 to 2 nanometers it will go through the oxide like a hot knife through butter*, there will be no problems at all." EX2022, 120:3-22. Finally, Ramappa reported that "[a]t temperatures above 900°C, there is a significant increase in the amount of iron that is transported into the Si bulk," *i.e.*, significantly more gettering, which confirms "there exists a diffusion temperature beyond which the oxide fail to mask the silicon bulk from the iron impurity incorporation." EX1025, 3775.

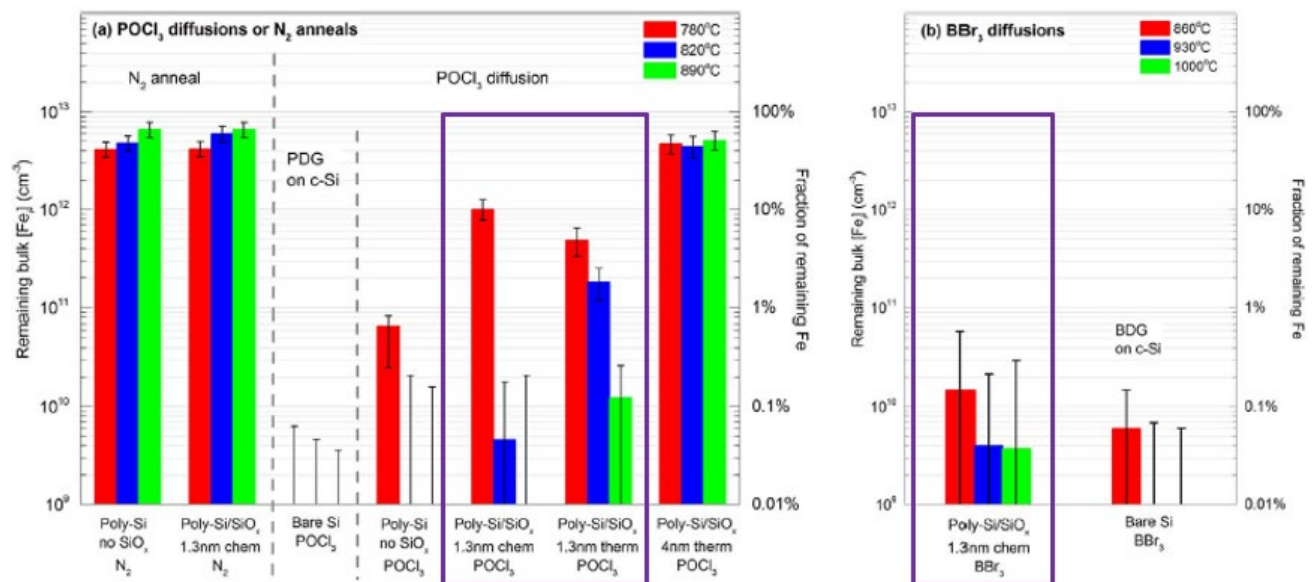
Maxeon's also argues it is significant that Li's polysilicon layer is undoped at the outset of the heating process. POR, 30-31. Maxeon is wrong.

- First, a Skilled Artisan would have understood that Li's polysilicon layer is doped to function as an "emitter" (as in the 315 Patent), which would have suggested "high doping to achieve the low resistance," which "in turn will give you strain in the poly[silicon] emitter... lead[ing] to gettering of the iron under these conditions." EX2022, 124:11-126:4. Dr. Carroll agrees Li suggests highly doped polysilicon. EX1087, 53:21-55:15, 73:7-14.

- Second, as of 2014 it was recognized that gettering occurs *simultaneously* with heat-driven dopant diffusion. EX1003, ¶¶85-86 (citing EX1018, 1; EX1010, 262; EX1016, 707); EX1087, 28:8-17. For example, Seibt noted that “phosphorous diffusion gettering” and “aluminum gettering” are “techniques predominantly applied in silicon photovoltaics” that both “getter[.]” and simultaneously “produce functional parts of the device, i.e. the highly phosphorus doped emitter and the backsurface field.” EX1016, 696-697. Hajjah also noted “[g]ettering processes, like Phosphorous doping, are known to reduce the detrimental impact of [iron] contamination during solar cell processing.” EX2032, 1. Liu-1 and Liu-2 extensively studied gettering of polysilicon concurrent with boron and phosphorous doping. EX1029, 138-39, Fig. 3.
- Third, Maxeon’s “pileup” calculation based on Ramappa’s experiments with undoped silicon (POR, 19-20) fail to account for increased gettering that results from simultaneous doping. EX1087, 84:5-22; EX1029, Fig. 3.
- Finally, Liu-2 confirmed that gettering of metal impurities through a thin oxide *will naturally result* even with *undoped* polysilicon, which

removed “*half* of the initial bulk [iron] concentration.” *Id.*; EX1087, 108:5-109:15.

Petitioner has also shown gettering will occur regardless of how Li's tunnel oxide is formed. POR at 26. Liu-2 confirmed that for chemical and thermal oxides heated above 900°C, ~99.9% of iron gettered out of the substrate to the simultaneously-doped polysilicon (purple boxes below):



EX1029, Fig. 3. EX2022, 121:11-124:21 (based on Liu-2, “regardless of the thickness of the oxide and how it’s grown, they’re all effective in terms of causing a certain degree of gettering” which “even in the worst case... is... 40 to 50 percent gettering”); EX1087, 110:1-111:22. The fact that gettering may be “more effective” for “chemically-grown oxide layer than for a thermally grown layer, all other things being equal” (POR, 27) is irrelevant, given that gettering occurs in either case and Li places *no restriction* on the type of oxide layer, thus permitting

either chemical or thermal oxides. EX1005, ¶0039; EX1087, 119:1-3, 184:13-185:8. Also, as in Liu-1 and Liu-2, Li's oxide first undergoes heating during dopant drive-in, thus disposing of Maxeon's concerns regarding the "thermal history" of the oxide layer. EX2021, ¶106; POR, 28-29; EX1029, 137, Fig. 1; EX1028, 2276, Fig. 1; EX1087, 186:5-187:2.

D. The Li-Muller Combination Would Result in Gettering

Maxeon argues the Li-Muller combination would exhibit less effective gettering than in the case of phosphorous doping. POR at 32-33. Maxeon ignores that the Li-Muller combination does not alter Li's dopant drive-in process for the *backside* polysilicon layer, which would occur *before* boron ion-implantation of the substrate's front surface. Pet., 57, 61, 64-66 (describing that Muller "is used for its disclosure of the front dopant concentration" which would be "independent of the fabrication of the back side of the solar cell[]"). The process of doping Li's backside polysilicon regions with boron and phosphorous via dopant source regions is the same in the Li-Muller combination as in all other combinations. EX1087, 202:14-203:16. Thus Maxeon's arguments regarding less effective gettering with ion-implanted boron on Li's *front surface* are unfounded.

E. Expressly Adding Gettering To Li's Manufacturing Process Would Have Been Obvious

Petitioner's Hu and Ramappa do more than merely "confirm" inherency, as Maxeon claims. POR, 38. As of 2014, there was great concern about increasing

solar cell efficiency by reducing recombination, and “gettering” was the “common[ly]” recognized technique for reducing impurities in silicon substrates. POR, 3-4; EX1087, 34:6-12, 71:1-18. As explained in the Petition, Hu and Ramappa’s teachings regarding gettering of metal impurities in silicon, polysilicon, and silicon oxides, and the known importance of removing impurities to increase cell efficiency, would have motivated a Skilled Artisan to “expressly getter metal impurities.” Pet., 71-73. Thus, although unnecessary in light of Li’s inherent gettering, the Skilled Artisan would have made any modifications to Li’s existing process steps (e.g., modifying heating processes) to ensure effective gettering of metal impurities into the doped polysilicon regions. EX1003, ¶¶82-90, 220-223; EX1087, 80:7-19.

II. PETITIONER HAS DEMONSTRATED MOTIVATION TO COMBINATION LI WITH KING, SWANSON, MARVIN, AND MULLER

Maxeon does not dispute that King, Swanson, Marvin, and Muller disclose dopant concentrations of “approximately less than or equal to $2 \times 10^{18} \text{ cm}^{-3}$ ” on the front portion of the silicon substrate, thus disclosing the relevant limitation of the 315 Patent.⁵ POR, 41; EX2021, ¶¶138, 142-143; EX1087, 188:17-189:3.

⁵ Maxeon does *not* dispute that Muller discloses a front-side portion of the silicon substrate having a “dopant concentration of *approximately less than or equal to*

Maxeon's only dispute regarding this limitation is that King, Swanson, and Marvin are "design-specific" and therefore "inapposite" to Li due to their "[f]undamental differences," and that "[d]rastic changes to Li" would be necessary to implement Muller with no "legitimate benefits to such modifications" but alleged "drawbacks." POR at 1-2, 40. Maxeon is wrong on all counts.

A. Li's Disclosure is Adaptable To Various Environments

Maxeon erroneously assumes Petitioner "contemplate[s] maintaining Li in a 1-sun (non-concentrator) environment," which it argues differentiates Marvin and Swanson-352. POR, 53-55. To the contrary, "Li does not limit its back-contact solar cell to low radiation or terrestrial environments." EX1003, ¶¶103, 128; EX1087, 171:18-172:8. Indeed, Li's stated "field of renewable energy" broadly spans all types of "back-contact solar cells," with no limitation to terrestrial, space, or concentrator applications. EX1005, ¶¶0003-0005. As such, a Skilled Artisan would have been motivated to combine Li with prior art discussing the optimum

$2 \times 10^{18} \text{ cm}^{-3}$ " or articulate a construction of that claim limitation. POR, 44-45, 56-61; EX2021, ¶¶149-153; EX1087, 63:14-19, 188:17-189:3. Any such argument is waived. Paper 14, 10. In any event, Muller contemplates "**peak doping concentrations** in the range of 1×10^{17} to $2 \times 10^{18} \text{ cm}^{-3}$," *i.e.* $2 \times 10^{18} \text{ cm}^{-3}$. EX1008, 267.

concentrations for Li's many use cases. EX1003, ¶¶103, 122-128; EX1087, 187:6-188:16.

A Skilled Artisan in 2014 would have recognized that there were a “finite number of identified, predictable solutions” to the front dopant concentration issue, each of which could be adapted to fit Li's broadly-adaptable back-contact solar cell, and thus selecting a concentration at or below approximately $2 \times 10^{18} \text{ cm}^{-3}$ would have, at a minimum, been “obvious to try.” *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 420-421 (2007) (particular method to fill “design need” left by the prior art was “obvious to try” where the art was “replete with [references]” pointing to that solution). Maxeon agrees that a Skilled Artisan “would have known to implement Li with whatever dopant concentration was appropriate under the circumstances.” POR, 47; EX1087, 156:18-159:5, 159:14-20, 201:11-202:13. Indeed, none of the “considerations” Maxeon argues would dictate a particular dopant concentration— “anticipated radiation exposure,” “shape of dopant profile,” “application” of the solar cell, and “thickness of silicon oxide passivation layer”—are restricted by Li's disclosure. POR, 48; *In re Heck*, 699 F.2d 1331, 1332-33 (Fed. Cir. 1983) (“The use of patents as references is not limited to what the patentees describe as their own inventions or the problems with which they are concerned. They are part of the literature of the art, relevant for all they contain” including where patent contains “broader disclosures” not limited to a “specific

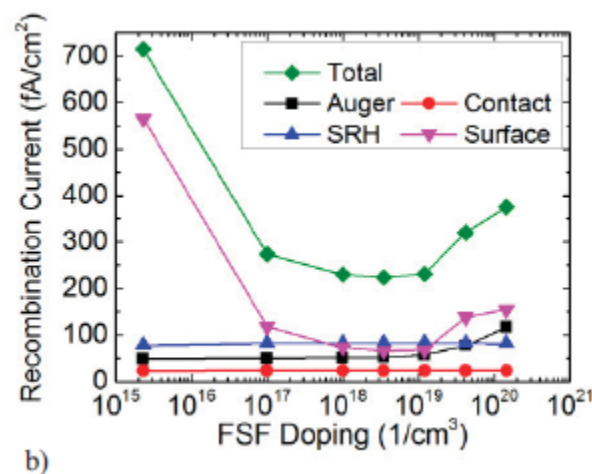
use”); *Netflix, Inc. v. DivX, LLC*, No. 2022-1083, 2023 WL 2298768, at *4 (Fed. Cir. Mar. 1, 2023).

King, Swanson-352, Marvin, and Muller supply the front dopant concentration for the doped front portion of Li's back-contact solar cell. EX1087, 188:17-189:3. All point to scenarios in which a dopant concentration of less than approximately $2 \times 10^{18} \text{ cm}^{-3}$ was optimal for back-contact solar cells. EX1006, 369; EX1015, 4:43-51; EX1035, 826-827; EX1007, 25, Table 7; EX1008, 267; *see also* EX1003, ¶¶74-80, 110, 113, 120-121, 124-128. A Skilled Artisan would have recognized the advantages of implementing King, Swanson-352, Marvin, or Muller's front surface doping and passivation strategies, including increased efficiency in the identified circumstances. EX1003, ¶¶110, 114, 123-127, 137-141. Doing so would have been straightforward, within the capabilities of a Skilled Artisan, and would have served Li's goal of increased efficiency. EX1005, ¶0005; EX1003, ¶¶126, 129-131. Incredibly, Dr. Carroll even confirmed that his *own* academic work on back-contact silicon solar cells in the 2010-2014 timeframe utilized a front surface dopant concentration of “*at or about 10^{18} cm^{-3}* ,” and that others in the industry may also have been making such products in that timeframe. EX1087, 40:5-45:9, 47:13-49:4, 63:20-64:16, 190:18-191:7.

B. Li's Disclosure Does Not Preclude Front-Side Oxide Passivation

Maxeon argues the art's allegedly thick front-surface silicon oxide passivation layer would be inconsistent with Li's disclosure. POR, 49-50, 56. Contrary to Maxeon's suggestion, Li does *not* preclude front-side oxide passivation (of any particular thickness). EX2022, 42:4-17 (“[W]hen a POSITA reads Li with her knowledge of the field, I think she will be inclined to use a passivating layer.”); *id.* 49:19-50:18, 52:18-56:4, 56:12-58:15. Instead, Li states that “well-known fabrication techniques... are not described in detail in order to not unnecessarily obscure embodiments of the present invention,” and “the process flows described” may even “include additional heating or annealing operation[s].” EX1005, ¶¶0021, 0024. Notably, before 2014 it was well-known that “excellent front surface passivation is one of the most important requirements of the back-junction cell type.” EX2015, 1. Dr. Carroll confirmed the known benefits of growing such a layer as of 2014, that manufacturing such a layer was low cost and straightforward, and that a Skilled Artisan would have known it would be a “bad idea” to implement Li's solar cell without front-surface passivation. EX1087, 46:11-47:12, 159:6-13, 159:21-163:10, 164:8-168:4, 192:13-193:19; *see also* EX2024, 1. Therefore, Maxeon's “critical” assumption that Li cannot employ a passivating oxide layer on the front surface (POR, 48-50, 54, 59) is baseless, and fails to distinguish King, Swanson-352, Marvin, or Muller.

Maxeon next argues that Lamers, Desa, and Procel suggest front dopant concentrations of $3 \times 10^{18} \text{ cm}^{-3}$, $1 \times 10^{19} \text{ cm}^{-3}$, and $3.47 \times 10^{18} \text{ cm}^{-3}$, respectively. POR, 45-46. But, these references do not reflect a “trend” to using only “thinner oxide layers and higher dopant concentrations” and away from King, Swanson, and Marvin, as Maxeon suggests. POR, 55. While Lamers noted an experiment that “decided to use a shallow and a high resistance FSF with a surface doping level of $3.10^{18} \text{ atoms/cm}^{-3}$,” it also noted there are circumstances where “a *lightly doped* and shallow FSF, with a high resistance in combination with good surface passivation, will give the *highest cell output*.” EX2024, 2. Similarly, Desa cautioned that “overdoping increases recombination” and can result in a “dead layer.” EX2025, 71. Finally, Procel found that, for a simulated solar cell, the “inflection point” at which front surface doping became counterproductive was at $3.47 \times 10^{18} \text{ cm}^{-3}$, but that doping at $1 \times 10^{18} \text{ cm}^{-3}$ produced about the same recombination:



EX2026, 129, 131, Fig. 4b. Thus, Procel suggested *against* higher dopant concentrations and toward concentrations in the range of approximately $2 \times 10^{18} \text{ cm}^{-3}$.³ Finally, as Dr. Carroll and Dr. Banerjee have explained, the art (*e.g.*, Granek) confirms that similar results can be achieved using *either* thin oxides with higher dopant profiles, *or* thicker oxides with lower dopant profiles, as these attributes are “related” in “improving cell efficiency.” EX2022, 28:17-32:7; EX2021, ¶133; EX2015, Fig. 4, Table II.⁶

Table II. Summary of the results for the textured samples with different front surface field diffusions.

n^+ diffusion [$\Omega/\text{sq.}$]	$\rho_{\text{base}} = 1 \Omega \text{ cm}$ low-level-injection		$\rho_{\text{base}} = 10 \Omega \text{ cm}$ high-level-injection	
	J_{0s} [fA/cm ²]	$V_{OC, Limit}$ [mV]	J_{0s} [fA/cm ²]	$V_{OC, Limit}$ [mV]
Thin Oxides {	32	1170	615	615
	73	290	651	651
	96	138	671	667
	353	31	36	706
	148 (deep)	38	40	703
no diffusion	27	714	31	710

Thick Oxide
(*e.g.*, King,
Swanson-352,
Marvin)

⁶ Granek cited King's dopant concentration study, undermining Maxeon's suggestion that the reference is “outdated.” POR, 55; EX2015, 2, 4; EX1087, 51:16-53:14 (agreeing that the solar industry remains deferential to Richard Swanson, inventor/author of King and Swanson-352).

EX2015, 4 (noting the deep diffusion thick oxide experiment “result[ed] in the lowest J_{0s} values” and “lowest surface phosphorous concentration”); EX1087, 199:5-20 (confirming Granek’s “thick oxide” example performed better than 3 of the 4 tested “thin oxide” examples, and second-best overall). Thus, Maxeon’s references do not instruct use of higher front surface dopant concentrations.

EX1087, 191:8-192:6, 201:11-202:13.

C. The Li-Muller Combination Would Not Have Required “Detrimental Changes” Or Resulted in “Drawbacks”

Maxeon argues combining Li with Muller’s front-side dopant concentration would necessitate “significant changes to Li” and “drawbacks” with no competing benefits. POR, 56, 60. Not so.

The benefits articulated by Muller would have motivated a Skilled Artisan to combine Li’s back-contact solar cell with Muller’s ion-implanted boron-doped FFE and associated passivation (which would replace Li’s phosphorous (n-type) doped FSF). Pet., 58-61; EX1003, ¶¶192-197. Specifically, Muller’s boron (i.e., p-type) ion-implanted FFE lowered recombination and exhibited greater resistance to UV degradation compared to a n-type-doped (phosphorous) ion-implanted FSF, which (together with known advantages of ion implantation generally) provides a clear reason to switch from Li’s n-type doping to Muller’s p-type doping.

EX1008, 269-271; EX1003, ¶¶193-194, 197; Pet. 60-64.

The Muller combination is consistent with Li's stated objective to adopt "techniques for increasing the efficiency of solar cells" and "processes for fabricating novel solar cell structures" in pursuit of increased cell efficiency. EX1005, [0005]. Far from a statement of "purpose" (Pet., 57), Li merely contemplated that "*[i]n some embodiments*, a reduction in the sheer number of process operations is achieved." EX1005, ¶[0024]. In fact, Li expressly contemplated undertaking "*additional* heating or anneal operation[s]" in order to achieve improved solar cell efficiency. *Id.*; EX1087, 180:8-183:9. Further, ion-implantation is reported as useful for "high-volume manufacturing of silicon solar cells" including specifically "back junction cells," with resulting "simplifi[cation of] fabrication of advanced cell structures" as well as "reduc[tion in] the complexity, number of processing steps and cost." EX1036, 10-11. Thus, Muller is fully consistent with Li's stated objectives.

The steps required to combine Li's solar cell with Muller's front-side doping and passivation technique are straightforward. Pet., 64-66, EX1003, ¶¶198-200; EX1087, 159:2-5207:1-208:4. Maxeon argues this would entail "additional processing steps" (EX2021, ¶151), but ignores that (i) Li permits separate steps for doping of the front and back portions of the solar cell, (ii) does not preclude (and indeed would have been expected to include) front-side passivation, (iii) and

expressly contemplates “additional heating or anneal operation[s].” EX2021, ¶106; *supra* §II.B.

Thus, the Petition fully explained the benefits of the Li-Muller combination and the absence of substantial drawbacks in manufacturing or efficiency.

III. CONCLUSION

Claims 10-16 and 19 should be cancelled as unpatentable.

Dated: July 1, 2025

Respectfully submitted,

/Samuel N. Tiu/

Samuel N. Tiu

Reg. No. 47,997

Sidley Austin LLP

350 S. Grand Avenue

Los Angeles, CA 90071

CERTIFICATE OF COMPLIANCE

I hereby certify that this brief complies with the type-volume limitations of 37 C.F.R. § 42.24, because it contains 5,589 words (as determined by the Microsoft Word word-processing system used to prepare the brief), excluding the parts of the brief exempted by 37 C.F.R. § 42.24.

Dated: July 1, 2025

Respectfully Submitted,

/Samuel N. Tiu/

Samuel N. Tiu

Reg. No. 47,997

Sidley Austin LLP

350 S. Grand Ave.

Los Angeles, CA 90071

Attorney for Canadian Solar Inc.

CERTIFICATE OF SERVICE

I hereby certify that on this 1st day of July, 2025, a copy of the foregoing and accompanying exhibits, has been served in its entirety by electronic mail on the following counsel of record for patent owner:

Jacob A. Snodgrass	jacob.snodgrass@pvuslaw.com
Bradford A. Cangro	bradford.cangro@pvuslaw.com
Jeremy D. Peterson	jeremy.peterson@pvuslaw.com
Jing Zhao	jing.zhao@pvuslaw.com
	Maxeon_SolarIPRService@pvuslaw.com

Dated: July 1, 2025

Respectfully submitted,

/Samuel N. Tiu/

Samuel N. Tiu

Reg. No. 47,997

Sidley Austin LLP

350 S. Grand Avenue

Los Angeles, CA 90071